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Bioremediation and Its Types: A Review

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ABSTRACT: Bioremediation is a process where degradation of contamination is done with the help of different microorganisms, which is one of the cost-effective methods that has been used until now. Giving optimum conditions to microorganisms it degrades the waste effluent in good percentage. Biostimulation, Bioaccumulation, Biopiles, Bioventing, Biosparging, Bioaugmentation, etc. are the types of Bioremediation. In today's world it is the safe process which is cost effective, less labour work and many more.

KEYWORDS: Bioremediation, Types, Microorganisms, Advantages.

I. INTRODUCTION

George M. Robinson, a petroleum engineer, basically invented bioremediation in the 1960s. He conducted research using bacteria in glass jars filled with contaminants. He experimented with introducing several bacteria kinds to the jars and discovered that some of them were effective at breaking down the contaminant. He presented his research to the scientific community, and finally his techniques were put to the test as a response to numerous environmental issues. Robinson is recognised with using microorganisms in a significant oil spill cleaning for the first time. Since his discoveries, the bioremediation technique has been used and enhanced to increase its potency and effectiveness. Today, bioremediation is employed worldwide to clear up all kinds of toxic spills [1].

A subject of biotechnology known as "bioremediation" uses live organisms, such as bacteria and microorganisms, to remove contaminants, pollutants, and pollutants from soil, water, and other environments. Treatment of polluted groundwater or environmental issues like oil spills may be accomplished via bioremediation. The process of bioremediation depends on promoting the growth of specific bacteria that use pollutants like oil, solvents, and pesticides as food and energy sources. These microorganisms also transform harmless such as carbon dioxide into modest amounts of water [2].

Either "in situ," which refers to the contamination site itself, or "ex-situ," which refers to a location other than the site, can be used for bioremediation. If the soil is too congested for nutrients to disperse evenly or the environment is too cold to support microbe activity, ex situ bioremediation might well be required. Removing and clearing the soil above ground may be necessary for ex situ bioremediation, which could result in a large increase in the process' expenses [3]. Depending on factors including the size of the contaminated region, the concentration of toxins, the temperature, the density of the soil, and whether bioremediation will take place in situ or ex-situ, the bioremediation processes may take several months to several years to complete [4].

PRINCIPLE

Microorganisms are well-suited for pollutant destruction because they have enzymes that allow them to consume environmental toxins as food. The goal of bioremediation is to encourage them to work by providing optimal amounts of the nutrients and other chemicals required for their metabolic activities in order to degrade/detoxify dangerous pollutants to the environment and living organisms. Enzymes mediate all metabolic processes. These enzymes are classified as oxidoreductases, hydrolases, lyases, transferases, isomerases, and ligases. Because of their non-specific and specific substrate affinity, many enzymes have a remarkable broad degradation capability. Microorganisms must enzymatically consume contaminants and transform them into harmless compounds for bioremediation to be effective. Since environmental circumstances must be favorable for microbial growth and activity for bioremediation to be effective, this process' application frequently includes changing environmental variables to promote microbial growth and degradation [5]. Natural bioremediation occurs and is enhanced by the addition of living creatures and fertilizers. The technology used in bioremediation is mostly based on biodegradation. It refers to the full conversion of harmful or naturally occurring organic contaminants into substances that are safe for people, animals, plants, and aquatic life, such

as carbon dioxide, water, and inorganic compounds. The microbial degradation of a wide range of organic compounds has been explained by a number of processes and routes; for instance, it may occur both with and without oxygen.

TYPES OF BIO-REMEDIATION

There are many treatment technologies or procedures used in bioremediation processes.

Some types of bio-remediation are:

- ⇒ Bio-stimulation.
- ⇒ Bio-attenuation.
- ⇒ Bio-augmentation.
- ⇒ Bio-accumulation.
- ⇒ Bioventing.
- ⇒ Biopiles.
- ⇒ Bioslurping.
- ⇒ Biosparging.

BIOSTIMULATION

Bio-stimulation involves changing the environment to activate existing microorganisms and increase their capacity for bioremediation. The environment's naturally occurring bacteria are stimulated by the addition of different nutrients and an electron acceptor [6]. The fundamental goal of biostimulation is to boost the quality of soil bacteria that may break down contaminants by adding more water, nutrients, and oxygen. Bio-stimulation is roughly divided into passive and active bio-stimulation depending on how nutrients are administered. In active bio-stimulation, trace elements, electron donors, and electron acceptors are released into the environment to encourage the growth of natural organisms, which leads to the breakdown of the pollutant. While there is no pumping involved with passive bio-stimulation, the nutrients are simply dispersed around the surface of the contaminated site.

In other words, this type of strategy involves the addition of particular nutrients to the area (soil or groundwater) in order to promote the activity of local microorganisms. The promotion of local or naturally occurring bacterial and fungal communities is its main emphasis. By first providing fertilizers, growth aids, and trace minerals. In order to enhance their metabolic rate and pathway, additional environmental needs including pH, temperature, and oxygen can be provided. [7,8]

The presence of a little quantity of pollution can also function as a stimulant by activating the operons for bioremediation enzymes. This sort of planned method is frequently continued in the delivery of nutrients and oxygen to aid indigenous microorganisms. These nutrients are the essential building blocks of life, allowing bacteria to develop basic requirements such as energy, cell biomass, and enzymes to breakdown the contaminant. They will all require nitrogen, phosphorus, and carbon [9].

BIOATTENUATION

The removal of pollutant concentrations from the environment is known as bio-attenuation or natural attenuation. It may be carried out in biological processes (aerobic and anaerobic biodegradation, plant and animal absorption), physical phenomena such as (dispersion, dilution, diffusion, volatilization, sorption/desorption), and biochemical processes (ion exchange, complexation, abiotic transformation). The description of natural attenuation includes terms like intrinsic remediation and biotransformation [10]. It involves the reduction in mass or concentration in groundwater of the compound of contaminant by the biological process

When pollutants damage the environment, nature may clean it up in four ways [11].

- 1) Some chemicals are consumed by tiny bugs or bacteria that reside in soil and groundwater. When the compounds are entirely digested, they can be converted into water and safe gases.
- 2) Chemicals can adhere to or bind to soil, keeping them in situ. This does not remove the chemicals, but it does prevent them from damaging groundwater and leaving the site.
- 3) Pollution can mix with pure water as it flows through soil and groundwater. This lessens or dilutes pollutants.
- 4) Some chemicals, such as solvents and oil, have the ability to evaporate, which implies that they can turn to liquids to gases inside soil. Sunlight may destroy these gases if they are allowed to escape into the air near the ground's surface.

Bioremediation will be accelerated through biostimulation or bioaugmentation if the rate or extent of natural attenuation is insufficient.

BIOAUGMENTATION

It is a type of biodegradation mechanism. Bioaugmentation is the technique of introducing pollutant-degrading microorganisms (natural, exotic, or synthetic) to a polluted region in order to increase the native microbial populations' ability for biodegradation. In order to promote degradation and quickly increase the number of naturally occurring microorganisms that selectively feed on contaminated sites. Microbes are taken from the remediation site, cultivated separately, genetically altered, and then released back onto the site. For evidence, tetrachloroethylene and trichloroethylene contamination of soil and groundwater results in the presence of all necessary microorganisms in such areas. It is utilized to make sure that the in-situ microorganisms can completely eliminate and transform these pollutants into non-toxic ethylene and chloride [12]. The chemical structure, concentration, and availability of contaminants, as well as various physicochemical features of the soil, all influence the process's performance. Bioaugmentation is the most powerful approach since organisms, rather than nutrients, are introduced into the polluted environment, as opposed to nutrients in the bio-stimulation process.

BIOACCUMULATION

Bioaccumulation is the metabolically required, energy-driven process through which metals are taken up by living cells. Toxins may be delivered into cells and deposit intracellularly throughout the cell membrane [13]. The word 'bioaccumulation' can be used in two ways: a) to describe a dynamic of passive or active absorption and accumulation of an element or compound within an organism; and b) in a static sense, referring to a currently high concentration as a result of prior accumulation processes. Similarly, the word 'bioconcentration,' which is frequently used interchangeably, refers to the direct absorption of chemicals from the environment into the organism (through plant roots, fish gills, and so on) rather than through ingested food. If the word 'bioconcentration' is therefore limited to direct absorption, then food chain uptake is sometimes referred to as 'biomagnification' or 'biological magnification.' A compartmental method treats each input (or inlet) and exit (or outlet) mechanism similarly [14].

BIOVENTING

Bioventing is the process of venting oxygen through soil to accelerate the growth of naturally occurring or imported bacteria and fungi in the soil by delivering oxygen to preexisting soil microorganisms; it is particularly useful in aerobically biodegradable compounds. Low air flow rates are used in bioventing to supply only enough oxygen to maintain microbial activity. The most prevalent method of supplying oxygen is by direct air injections into residual pollution in soil via wells. Adsorbed fuel particles are biodegraded, as are volatile chemicals as they travel progressively through biologically active soils. Many researchers have demonstrated the effectiveness of bioventing in the cleanup of petroleum-contaminated soil [15,16].

BIOPILES

Excavated soil that contains hydrocarbons that can be treated aerobically can be processed in "biopiles." During the biodegradation process, biopiles (also called biocells, bioheaps, biomounds, and compost piles) is employed to lower petroleum pollutant in excavated soils. Air is provided to the biopile system during this process via a network of pipes and pumps that either pushes air into the pile under high pressures or pulls air through the pile under compression [17]. Microbial activity is increased through microbial respiration, and the result is a high level of decomposition of adsorbed petroleum pollutants [18].

BIOSLURPING

Utilizing indirect oxygen provision and promotion of contaminant biodegradation, this technology involves pressure pumping, soil vapor extraction, and venting to accomplish soil and groundwater cleanup [19]. In this method, too much soil moisture restricts air permeability and slows the pace at which oxygen is transferred, which in turn lowers microbial activity. The method saves money because it produces less groundwater as a result of the operation, which reduces the expenses associated with storage, treatment, and disposal even if it is not appropriate for remediating soil with poor permeability [20]. One of the main issues with this specific in situ approach is creating a vacuum on a deep,

very permeable site. Another is the changing water table, which might lead to saturated soil layers that are challenging to aerate.

BIOSPARGING

This method is similar to bioventing in that gas is pumped into the subsurface of the soil to encourage microbial activity and increase pollution removal from contaminated locations. Unlike bioventing, however, the air is pumped at the saturated area to enhance biodegradation by causing upward migration of volatile organic molecules to the unsaturated area. Biosparging efficacy is determined by two key factors: soil permeability, which impacts pollutant availability to organisms, and pollutant biodegradability [20]. Biosparging had been frequently used for the treatment of polluted aquifers with petroleum compounds, particularly diesel and kerosene.

ADVANTAGE OF BIOREMEDIATION

- As a suitable waste treatment technique for polluted material such as soil, it is a natural process that takes some time. Microbes may decompose the contamination and multiply when the pollutant is present. The biodegradative population decreases as the pollutant degrades. The treatment leftovers are often products such as water, carbon dioxide, and cell biomass.
- It needs very little effort and is frequently performed on-site, generally without causing significant disruption to usual activity. This also removes the need to transfer large amounts of garbage away from the site, as well as the possible hazards to the environment and human health that might occur during the transfer.
- It is employed in a cost-effective procedure since it loses less than other traditional processes (technologies) used for hazardous waste cleanup. A critical strategy for treating oil-contaminated areas [21].
- It helps in the full elimination of pollutants, since many dangerous substances may be converted to non-toxic products, and it also eliminates the possibility of future responsibility related to the treatment and removal of contaminated material.
- It does not make use of any hazardous substances. Nutrients, particularly fertilizers, are provided to promote active and rapid microbiological development. Typically used over lawns and in gardens. Because bioremediation converts dangerous chemicals into harmless gases and water, the toxic substances are fully removed [22]
- Because of their essential role in the ecology, they are simple, less labor demanding, and inexpensive.
- Eco-friendly and long-lasting [23].
- Contaminants are eliminated rather than merely transported to other environmental medium.
- Relatively simple to implement [24].
- Effective method of removing contaminants from natural ecosystems while being environmentally beneficial [25].

CONCLUSION

Bioremediation is a technique for clearing up pollution by increasing natural biodegradation processes. Therefore, these opportunities provide the possibility for major advancements through increasing our knowledge of microbial populations and how they respond to the environment and contaminants, growing our understanding of the genetics of microbes to boost their capacity to degrade pollutants, performing field tests of the novel, cost-effective bioremediation approaches, and designating areas which have been set aside for long-term research purpose view. Without a question, bioremediation is leading the path to greener pastures. Regardless of whether component of bioremediation is employed, this method provides an efficient and cost-effective solution to clean polluted groundwater and soil. The number of sites that prefer to utilize this technique and its rising popularity shows that its benefits typically outweigh its drawbacks. Once more, bioremediation technology is responsible for cleaning up the contaminated environment and might be employed as a management tool.

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